The opinion in support of the decision being entered today was *not* written for publication and is *not* binding precedent of the Board.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte ANDRAS KUTHI
and LUMIN LI

Appeal 2006-1796
Application 09/611,037
Technology Center 1700

Decided: September 20, 2006

Before KIMLIN, WARREN, and JEFFREY T. SMITH, *Administrative Patent Judges*.

WARREN, *Administrative Patent Judge*.

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134 from the decision of the Examiner twice rejecting claims 14 through 21 and 33 through 40,[1] all of the claims in the application.

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[1] See the non-final action mailed May 13, 2005.

Claims 14, 33 and 37 illustrate Appellants' invention of methods for processing a semiconductor wafer, and are representative of the claims on appeal:

14. In a chamber for processing a semiconductor wafer through plasma etching operations, the chamber being in an operational state and including a support chuck for holding the semiconductor wafer, a pair of RF power sources, and a top electrode, a method for processing a semiconductor wafer through plasma etching operations, comprising:

striking a plasma in a plasma region of the chamber; and

generating an increase in bias voltage directed at a wafer surface of the semiconductor wafer and a decrease in bias voltage directed at the top electrode, the top electrode having a center region, a first surface and a second surface, the first surface having an inlet that is configured to receive processing gases from a source that is external to the chamber and flow the processing gases into the center region, the second surface having a plurality of gas feed holes that lead to a plurality of electrode openings that have electrode opening diameters that are greater than gas feed hole diameters of the plurality of gas feed holes, the plurality of electrode openings being configured to define the second surface which is located over the wafer surface of the semiconductor wafer,

wherein when a plasma is struck in the plasma region defined between the second surface and the wafer surface, the plasma defines a first plasma sheath surface having a first plasma sheath surface area that is proximate to the wafer surface and a second plasma sheath surface having a second plasma sheath surface area that is proximate to the second surface, the second plasma sheath surface area being greater than the first plasma sheath surface area.

33. A method of processing a semiconductor wafer, comprising:

providing a processing chamber, the processing chamber being in an operational state and including a top electrode, a wafer support chuck having the semiconductor wafer positioned thereon, and a pair of RF power sources;

striking a plasma within a plasma region of the processing chamber; and

causing a first surface of a plasma sheath to shift into electrode openings of the top electrode,

wherein the plasma sheath defines the first surface of the plasma sheath next to the top electrode and a second surface of the plasma sheath over a surface of the semiconductor wafer.

37. A method for high aspect ratio semiconductor etching, comprising:

providing a plasma etch processing chamber, the plasma etch processing chamber including a top electrode, a wafer support chuck, and a pair of RF power supplies, and the plasma etch processing chamber being configured in an operational state;

striking a plasmas in a plasma region of the plasma etch processing chamber, the plasma region being defined between an electrode surface of the top electrode and a wafer surface of a wafer positioned on the wafer support chuck;

causing a first surface of a plasma sheath to shift into electrode openings of the top electrode, the first surface of the plasma sheath being proximate to the top electrode; and

increasing a bias voltage over the wafer surface while decreasing the bias voltage over the electrode surface of the top electrode and without increasing a plasma density.

The references relied on by the Examiner are:

Chang	US 4,854,263	Aug. 8, 1989
Tomita	US 5,593,540	Jan. 14, 1997

The Examiner has advanced the following grounds of rejection on appeal: claims 33 through 35, 37, 38, and 40 under 35 U.S.C. § 103(a) as being unpatentable over Tomita in view of the admitted prior art in the specification (specification 1-5 and **FIGs. 1**A-E) (Answer 4-5); claims 14 through 21 and 33 through 40 under 35 U.S.C. § 103(a) as being unpatentable over the admitted prior art in the specification (specification 1-5 and **FIGs. 1**A-E) in view of Chang (*id.* 5-8); claims 14 through 21 and

33 through 40 under 35 U.S.C. § 103(a) as being unpatentable over Chang in view of the admitted prior art in the specification (specification 1-5 and **FIGs. 1**A-E) (*id.* 8-11).

Appellants argue the claims as a group with respect to each of the grounds of rejection. Thus, we decide this appeal based on appealed independent claims 14, 33, and 37 as representative of the grounds of rejection and Appellants' groupings of claims. 37 C.F.R. § 41.37(c)(1)(vii) (2005).

We affirm.

We refer to the Answer and to the Supplemental Brief[2] and Reply Brief for a complete exposition of the positions advanced by the Examiner and Appellants.

OPINION

We have carefully reviewed the record on this appeal and based thereon find ourselves in agreement with the supported position advanced by the Examiner that, prima facie, the claimed methods for processing a

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[2] We have considered Appellants' arguments only to the extent that they appear in the Supplemental Brief filed September 15, 2005, including the specific reference therein to the inherency argument in the Brief filed March 7, 2005 (Supplemental Br. 4-5: bridging paragraph; Br. 5-8). Indeed, the other arguments in the Brief refer to a ground of rejection not before us on appeal. In this respect, 37 CFR § 41.37(c)(1)(vii) (2005) provides in pertinent part: "Any arguments or authorities not included in the brief or reply brief filed pursuant to § 41.41 will be refused consideration by the Board, unless good cause is shown." See also Manual of Patent Examining Procedure (MPEP) §§ 1205.02 (8th ed., Rev. 3, August 2005). Likewise, we have considered the Examiner's arguments only to the extent that they appear in the Answer. See MPEP § 1207.02 (8th ed., Rev. 3, August 2005).

semiconductor wafer encompassed by appealed claims 14, 33, and 37 would have been obvious over the combined teachings of Tomita and the admitted prior art with respect to claims 33 and 37, and of the admitted prior art and Chang with respect to claims 14, 33, and 37 to one of ordinary skill in this art at the time the claimed invention was made. Accordingly, since a prima facie case of obviousness has been established by the Examiner, we again evaluate all of the evidence of obviousness and nonobviousness based on the record as a whole, giving due consideration to the weight of Appellants' arguments in the Supplemental Brief and Reply Brief and to the evidence in the Li Declaration[3] to the extent argued therein. *See generally, In re Oetiker*, 977 F.2d 1443, 1445, 24 USPQ2d 1443, 1444 (Fed. Cir. 1992); *In re Piasecki*, 745 F.2d 1468, 1472, 223 USPQ 785, 788 (Fed. Cir. 1984).

We substantially agree with the Examiner's findings of fact from the references and admitted prior art, and conclusions of law based on this substantial evidence as set forth in the Answer, to which we add the following for emphasis.

The issues in this appeal involve the "electrode openings" of the "top electrode" specified in each of claims 14, 33, and 37. In claims 33 and 37, the "electrode openings" are specified to be "of the top electrode." Claim 14 specifies that the "electrode openings" are in communication with the "gas feed holes," have "diameters that are greater than the gas feed holes," and are stated to "define" the "second surface" of the "top electrode" that is "located over the wafer surface." The claims further specify "striking a

[3] Declaration under 37 C.F.R. § 132 by Dr. Lumin Li executed September 3, 2003, and filed September 4, 2003

plasma" between the second surface of the top electrode and the wafer surface, and claims 14 and 37 further specify that a "plasma sheath surface" is at the top electrode and at the wafer surface. In claims 33 and 37, the plasma sheath surface at the top electrode "is caused to shift" into the "electrode opening." Claim 37 further specifies "increasing a bias voltage over the wafer surface while decreasing the bias voltage over the [top] electrode surface . . . without increasing a plasma density," and claim 14 specifies "generating an increase in bias voltage directed at a wafer surface . . . and a decrease in bias voltage directed at the tope electrode" and the "plasma sheath surface area" at the second surface of the top electrode is greater than that at the wafer surface.

We do not find in the specification a definition for the term "electrode openings." We determine that one skilled in the art would have determined from the context in which this term is used in the claims and in the written description in the specification that the "openings" are formed in and through the electrode layer or plate that forms the "second" or electrode surface of the top electrode, and that the "gas feed holes" communicate with the plasma region of the chamber therethrough. Thus, following the language of the claims and the written description in the specification, this person would reasonably consider the claim term to include the side surfaces of the openings through electrode surface **134** for gas feed line holes **128** to communicate with the chamber in prior art top electrode **114** (specification **FIG. 1**C). This person would also consider the term to include the side surfaces of "small holes" **55***b* in cathode plate **54** on the surface of top shower electrode **3** below gas feed holes **55***a* in the plasma

etching apparatus disclosed by Tomita (Tomita col. 3, ll. 58-64, col. 4, l. 66, to col. 5, l. 20, and **FIGs. 1, 2** and **4**). We find no basis in the claim language or in the written description in the specification which would limit the claim term "electrode openings" to electrode openings **202b** in the electrode surface **234** of top electrode **200** in specification **FIGs. 2**A and 2E (specification 11-12) or any other disclosed embodiment.

Thus, we interpret claims to require conducting the methods so that at least some portion of the surface area of the plasma sheath next to the top electrode "shifts into the electrode openings," that is, enters the electrode openings, to any extent, even into the gas feed holes, which can occur during operation of the chamber, such as when the surface area of the plasma sheath next to the surface of the top electrode is greater to any extent than the surface area of the sheath next to the wafer surface, causing an increase to any extent in bias voltage over the wafer surface and a decrease to any extent over the electrode surface of the top electrode. *See, e.g., In re Am. Acad. of Sci. Tech. Ctr.*, 367 F.3d 1359, 1364, 70 USPQ2d 1827, 1830 (Fed. Cir. 2004); *In re Morris*, 127 F.3d 1048, 1054-55, 44 USPQ2d 1023, 1027 (Fed. Cir. 1997); *In re Zletz*, 893 F.2d 319, 321-22, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989).

Considering first the ground of rejection of claims 33 and 37 based on the combined teachings of Tomita and the admitted prior art, the Examiner submits that the plasma sheath will inherently shift into electrode openings **55***b* of the top electrode of Tomita which can have a diameter of 0.6 mm to smaller than 0.8 mm, relying on the disclosure by Appellants that "[b]ecause the electrode openings 202b have been increased to be at least equal to or

greater than about 0.5 mm, a plasma sheath 231 is caused to shift into the electrode openings 202b" in the specification at page 13, ll. 22-24 (Answer 5 and 14; see Tomita, e.g., col. 2, ll. 31-34, col. 4, l. 65, to col. 5, l. 5, and **FIG. 2**). The Examiner further submits that prima facie one of ordinary skill in this art would have modified the plasma etching apparatus of Tomita to use two RF power sources, which configuration is known "to be a suitable structure for a plasma etching apparatus" in the art as evinced by the admitted prior art (Answer 5).

Appellants submit that inherency cannot be solely supported by the size of the diameter of the electrode openings disclosed in Tomita (Br. 5-6; see Supplemental Br. 4-5). In this respect, Appellants point to the structural difference between the electrode openings in the electrode surface illustrated in specification **FIG. 2**E and in Tomita **FIG. 4**, pointing out that in the latter structure, the gas line holes **55***a* are larger than the electrode openings **55***b* (Br. 7). Appellants contend that the Tomita structure "is constructed in such manner as to prevent plasma flow into the electrode openings" and thus, "teach away from such plasma flow" (*id.* 7-8). Appellants further point to the testimony in the Li Declaration at ¶ 8 (*id.* 8):

> A diameter of 0.6 mm does not inherently shift the plasma sheath into the openings and create a surface area next to the electrode that is larger than the surface area that is next to the wafer" and that "those skilled in the art . . . would not modify the reference in such manner as to increase size of the holes and purposely create plasma inside holes.

Appellants further submit that Tomita does not teach or suggest the claimed method, as the method of the reference has the objective to prevent or suppress polymerization within the gas feed holes of the top electrode

and does not disclose the formation of a plasma sheath (Supplemental Br. 5). Appellants contend that "the term 'shifting' is and must be read in light of Applicant's disclosure, which makes it clear that it is not simply 'incidental' (see page 17, and Figures 3-5)" (*id.*).

The Examiner responds that the plasma is present within the electrode holes of Tomita as evinced by the disclosure of plasma polymerization therein at col. 2, ll. 37-53, contending that the size of the electrode openings allow for shifting of the plasma sheath therein (Answer 12). The Examiner contends that the same disclosure in Tomita teaches that the term "suppressed" means that even with an increase in gas flow rate, "some plasma will still be present" in the electrode openings (*id.* 12). The Examiner submits that "appellant's method of 'shifting' the plasma sheath into" electrode opening is by providing openings with a diameter of at least 0.5 mm, and argues that the term "shifting" does not patentably distinguish the method of Tomita "in which a plasma sheath will inherently 'shift' into" the electrode openings (*id.* 12-13).

Appellants reply that while there is a relationship between the size of the electrode openings and the presence of the plasma sheath therein, pointing out that "to cause a . . . surface of a plasma sheath to shift into electrode openings, the size of the openings must be larger than the plasma sheath thickness" (Reply Br. 3). Appellants submit that "plasma sheath thickness is affected by a number of parameters" and different parameters means that the "plasma sheath thickness could be larger than 0.6 mm or 0.8 mm" and thus, "the plasma sheath would not necessarily shift into the

electrode openings, even when the electrode openings are greater than 0.5 mm" (*id.*).

In the Reply Brief, Appellants submit for the first time that Tomita does not disclose an apparatus having two RF power sources as claimed but teaches an RF power source for top electrode **3** and a DC power source for chuck electrode **61** (Reply Br. 3). Appellants contend that "[t]he pair of RF power sources affect the sinusoidal RF voltage waveforms (both in magnitude and frequency) shown in Figure 4A and would consequently affect the magnitudes of current and time in Figure 4B and bias versus area ratio of Figure 5," and argue that Tomita's "single RF power source (primarily for generating plasma) and single DC power source would generate a different bias voltage plot from voltage wave 302' [sic, 302] of Figure 4A" (*id.* 3-4; see also specification 15-17). Appellants further contend that it would not have been obvious to modify Tomita to have two RF power sources as described in the admitted prior art because a change in power could change Tomita's etching method (Reply Br. 4). Appellants argue that the admitted prior art employs a different power to generate a plasma than does Tomita and the modification would require "further engineering development" (*id.*).

We find that Tomita would have disclosed to one of ordinary skill in this art a method of plasma etching a semiconductor wafer in a chamber wherein the electrode holes or openings **55***b* in top shower electrode **3** can have a diameter in range of 0.6 mm to less than 0.8 mm and that under conventional operating conditions of low plasma-forming gas flow speed, "a plasma polymerization is likely to take place within the small holes"

resulting in polymer deposits **56** on the walls thereof (Tomita, e.g., col. 2, ll. 28-43, col. 3, ll. 58-64, col. 4, l. 66, to col. 5, l. 20, col. 5, ll. 34-38, col. 7, ll. 7-12, and **FIGs. 1**, **2**, **4**, **13**, and **14**). Tomita would have taught that this result can be remedied by increasing the gas flow rate to the extent that "[e]ven if a polymer is formed, the polymer is blown away by the gas stream flowing at a high speed" and thus, "[i]t follows that the polymer is unlikely to grow into bulky lumps" (Tomita, e.g., col. 2, ll. 43-53, and col. 5, ll. 38-42). Tomita would have disclosed that top shower electrode **3** is connected to a high frequency power source with chuck electrode **61** connected to ground to form a plasma generating circuit to generate a bias voltage, and chuck electrode **61** is further supplied with power from a DC power source (Tomita, e.g., col. 3, l. 62, to col. 4, l. 3, col. 4, ll. 44-50, and col. 5, ll. 21-33).

The method of plasma etching a semiconductor wafer disclosed as admitted prior art is described as employing a chamber wherein gas feed line holes **128** open through electrode surface **134** in top electrode **114** and RF power supplies **118a** and **118b** are connected to top electrode **114** and chuck **14**, respectively (specification 1-3 and **FIGs. 1**A and 1C). In operation, "[o]nce the process gases are channeled into the top electrode 114 and allowed to flow out of the gas feed holes 128 into plasma region 112, a plasma sheath 131 and 132 will be defined within the plasma region 112 as shown in Figure 1C" (specification 3:5-8).

We find substantial evidence in the combined teachings of Tomita and the admitted prior art which supports the Examiner's positions. We cannot agree with Appellants position that the combined teachings of the

applied prior art would not have led one of ordinary skill in this art to the claimed methods. We initially point out that neither claim 33 nor claim 37 specify the manner in which the RF power sources are applied in the plasma etch processing chamber, and thus, these claims are not limited to the sinusoidal RF voltage wave forms of "one embodiment" shown in Figure 4A (specification 15-17) as Appellants argue. Indeed, we find no basis in the claim language or in the written description in the specification to read the limitations of this embodiment into the claims. Thus, Appellants' arguments in this respect are not persuasive. *See generally, In re Self*, 671 F.2d 1344, 1348-49, 213 USPQ 1, 5 (CCPA 1982). Furthermore, we find in the combined teachings of the references substantial evidence supporting the position that one of ordinary skill in this art would have the knowledge to adjust the result effective bias voltage using conventional power sources in the art disclosed in Tomita and the admitted prior art to obtain a plasma in the etching chamber following the teachings of Tomita and would have developed a workable or optimum operating power range in this respect. *See In re Aller*, 220 F.2d 454, 456-58, 105 USPQ 233, 235-37 (CCPA 1955) ("[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.").

Thus, the dispositive issue is whether one of ordinary skill in this art routinely following the combined teachings of the applied prior art would have reasonably arrived at the claimed method encompassed by claims 33 and 37 including all of the limitations thereof. We agree with the Examiner's finding that it reasonably appears that during plasma etching

operations in the Tomita chamber as described in the reference, the plasma sheath will inherently shift into electrode openings **55***b* in top shower electrode **3**. This is because, as the Examiner points out, Tomita would have disclosed that plasma polymerization can take place in electrode openings of 0.6 mm to about 0.8 mm even at a high rate of plasma-forming gas flow and indeed, Appellants disclose that the plasma sheath will shift into an electrode opening having a diameter of "≥0.5 mm" (specification 13:3-4 and 22-24). Thus, on this record, the burden shifts to Appellants to submit effective argument or evidence patentably establishing otherwise. *See, e.g., In re King*, 801 F.2d 1324, 1326-28, 231 USPQ 136, 138-39 (Fed. Cir. 1986) (prior art device prima facie inherently performed the function disclosed in the claimed method when in "normal and usual operation," sifting the burden to Appellant to prove that device dose not perform the method as claimed); *In re Best*, 562 F.2d 1252, 1254-55, 195 USPQ 430, 432-33 (CCPA 1977) (conclusion that prior art method necessarily inherently performed the claimed functions based on the disclosure in the reference was reasonable, sifting the burden to Appellant to prove by effective argument and evidence the prior art method does not do so even though the reference is silent on the matter).

We are of the opinion that Appellants have not carried their burden. In the Reply Brief, Appellants admit a relationship between the size of the electrode opening and the presence of the shifted plasma sheath surface therein, but contend that the size of the electrode "opening must be larger than the plasma sheath thickness" which is affected by a number of parameters and may be larger than the electrode opening. The difficulty that

we have with Appellants' arguments is that they are unsupported by scientific reasoning and/or objective evidence and in any event do not address the limitations in claims 33 and 37. In this latter respect, we determined that these claims require only that the surface of the plasma sheath shifts into the electrode openings to any extent and that claims are not limited to either the structure of the electrode openings or the extent occupied by the electrode sheath illustrated in specification **FIGs. 2**A and **2**E (*see above* p. 7). We further note here that these claims do not require the electrode opening to have a greater diameter than the gas feed hole. Thus, we are of the view that Appellants' arguments are not persuasive on this basis alone. *See generally, Self*, 671 F.2d at 1348-49, 213 USPQ at 5.

Furthermore, Appellants' reliance on the embodiment illustrated in specification **FIGs. 2**A and **2**E is misplaced. While this disclosure illustrates that the shift has occurred, it does not establish that the shift in fact does not occur following the teachings of Tomita. Appellants' further allegation that the structure of the electrode opening and communicating gas feed hole illustrated in Tomita **FIG. 4** is structured to prevent plasma flow into the electrode opening is contrary to the apparent teachings of the reference on this record that such flow can and does occur in that structure and indeed, there is no teaching in Tomita to modify the structure. In similar manner, the testimony of Dr. Li at ¶ 8 of his declaration relied on by Appellants in the Brief asserts that an electrode opening diameter of 0.6 mm does not inherently shift the plasma sheath into the opening and affect the surface area thereof without reference to the method and apparatus of Tomita. Dr. Li's further assertion that one skilled in the art would not have

modified Tomita by increasing the size of the electrode openings overlooks the fact that the issue involves the method taught by Tomita for the apparatus disclosed therein and not a modification to the apparatus disclosed therein. Thus, we are unconvinced by Appellants' arguments and testimonial evidence. *See King*, 801 F.2d at 1327-28, 231 USPQ at 139; *Best*, 562 F.2d at 1255, 195 USPQ at 433.

Turning now to the ground of rejection based on the combined teachings of the admitted prior art and Chang, the Examiner submits that prima facie one of ordinary skill in this art would have modified the top electrode of the apparatus of the admitted prior art to have electrode openings that have a greater diameter than the gas feed holes in order to enhance gas dissociation and reactivity as taught by Chang (Answer 6-7). The Examiner further contends that the plasma sheath surface next to the top electrode will shift into the electrode openings of Chang, pointing to the disclosure in the specification at page 13, ll. 22-24, and in Change at col. 6, ll. 24-26, with respect to electrode opening diameter (Answer 7). The Examiner also takes the position that one of ordinary skill in the art would have modified the apparatus of Chang to include several of the components contained by the apparatus of the admitted prior art (*id.* 10).

Appellants submit that the combined teachings of the admitted prior art and Chang do not address the claim limitations (Supplemental Br. 6). The Examiner responds that the plasma sheath surface will inherently form within the electrode openings taught by Chang in view of the disclosure in the specification that the plasma sheath surface will shift into electrode openings of at least 0.5 mm, pointing out that Chang would have disclosed

an electrode opening of 4.82 mm which is within Appellants' preferred range of 2-10 mm as disclosed in the Li Declaration at ¶ 5 (Answer 13-14).

Appellants reply that the apparatus of Chang is a plasma enhanced vapor deposition chamber and not an etching chamber as they describe, and thus has different components and is operated under different conditions (Reply Br. 5). Thus, Appellants submit that it would not have been obvious "to combine the teachings of a deposition chamber with the teachings of an etching chamber" (*id.*).

We disagree with Appellants' position. Contrary to Appellants' contentions, Chang would have disclosed to one of ordinary skill in this art that the invention applies "to CVD reactors in general and to parallel plate plasma reactors in particular which are used to deposit thin films and, still more generally, to any process which uses an inlet aperture for supplying gasses across a pressure differential" (col. 11, ll. 9-16). Thus, the combined teachings of the admitted prior art and Chang provide substantial evidence in support of the Examiner's position.

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of obviousness found in the combined teachings of Tomita and the admitted prior art and of the admitted prior art and Chang as applied by the Examiner with Appellants' countervailing evidence of and argument for nonobviousness and conclude that the claimed invention encompassed by appealed claims 14 through 21 and 33 through 40 would have been obvious as a matter of law under 35 U.S.C. § 103(a).

The Examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv) (2006).

AFFIRMED

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